

GAUHATI UNIVERSITY

SYLLABUS
FOR
SIX SEMESTER DEGREE (B.Sc.) COURSE IN
GEOLOGY (MAJOR)

[Revised & Modified from the Syllabus introduced in 2003 and developed in the pattern of the UGC Model Curriculum in Earth Sciences, 2001]

2010

GAUHATI UNIVERSITY

Gopinath Bardoloi Nagar
Guwahati – 781 014
ASSAM, INDIA

DISTRIBUTION OF MARKS FOR THE MAJOR SPECIALISATION ELECTIVE IN GEOLOGY

The new B.Sc. (Major) course in Geology is a **Six semester course** and the Final Examinations will be conducted by the University at the end of each semester. The total marks of the course is **1700** and the semester wise distribution of marks is as follows :

FIRST SEMESTER

[Total Marks : 200]

| | <u>Marks</u> | |
|-------------------------------------|--------------|-----------------------------------------------------------------------------------------------------------------|
| Paper – 101 (<i>Theory</i>) | 75 | Group – A : General Geology, Group – B : Geomorphology, Group – C : Basic Principles of Remote Sensing |
| Paper – 102 (<i>Theory</i>) | 75 | Group – A : Crystallography Group – B : X-Ray Crystallography |
| Paper – 103 (<i>Practical</i>) | 50 | Unit – I : Crystallography Unit – II : Geomorphology |

SECOND SEMESTER

[Total Marks : 200]

| | <u>Marks</u> | |
|-------------------------------------|--------------|---------------------------------------------------------------------|
| Paper – 201 (<i>Theory</i>) | 75 | Optical Mineralogy |
| Paper – 202 (<i>Theory</i>) | 75 | Physical & Descriptive Mineralogy |
| Paper – 203 (<i>Practical</i>) | 50 | Unit – I : Mineral hand specimens Unit – II : Optical Mineralogy |

THIRD SEMESTER

[Total Marks : 200]

Marks

| | | |
|-------------------------------------|----|-------------------------------------------------------------------------------------------------------------------------------------------------|
| Paper – 301 (<i>Theory</i>) | 75 | Group – A : Structural Geology Group – B : Geotectonics |
| Paper – 302 (<i>Theory</i>) | 75 | Petrology - I |
| Paper – 303 (<i>Practical</i>) | 50 | Unit – I : Exercise on Geological contoured maps Unit – II : Structural Geology problems Unit – III : Geological Field Work - I |

FOURTH SEMESTER

[Total Marks : 200]

Marks

| | | |
|-------------------------------------|----|-----------------------------------------------------------|
| Paper – 401 (<i>Theory</i>) | 75 | Group – A : Crystal Chemistry Group – B : Geochemistry |
| Paper – 402 (<i>Theory</i>) | 75 | Petrology -II |
| Paper – 403 (<i>Practical</i>) | 50 | Igneous & Metamorphic Petrology |

FIFTH SEMESTER

[Total Marks : 450]

Marks

| | | |
|----------------------------------|----|-------------------------------------------------------|
| Paper – 501 (<i>Theory</i>) | 75 | Principles of Stratigraphy & Historical Geology |
| Paper – 502 (<i>Theory</i>) | 75 | Indian Stratigraphy |
| Paper – 503 (<i>Theory</i>) | 75 | Group – A : Palaeontology Group – B : Soil Geology |
| Paper – 504 (<i>Theory</i>) | 75 | Group – A : Hydrogeology |

| | | |
|-------------------------------------|----|---------------------------------------------------------------------------------------------------------|
| | | Group – B : Remote Sensing & GIS |
| Paper – 505 (<i>Practical</i>) | 75 | Unit – I : Sedimentary Petrology Unit – II : Palaeontology |
| Paper – 506 (<i>Practical</i>) | 75 | Unit – I : Surveying Unit – II : Indian Rock types Unit – III : Geological Field Work - II |

SIXTH SEMESTER

[Total Marks : 450]

| | <u>Marks</u> | |
|-------------------------------------|--------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Paper – 601 (<i>Theory</i>) | 75 | Group – A : Ore Genesis Group – B : Prospecting |
| Paper – 602 (<i>Theory</i>) | 75 | Group – A : Indian Mineral Deposits Group – B : Mineral Economics |
| Paper – 603 (<i>Theory</i>) | 75 | Group – A : Environmental Geology Group – B : Engineering Geology |
| Paper – 604 (<i>Theory</i>) | 75 | Group – A : Fuel Geology Group – B : Mining Geology |
| Paper – 605 (<i>Practical</i>) | 75 | Unit – I : Economic Geology Unit – II : Reserve Estimation & Ore Microscopy Unit – III : Remote Sensing Unit – IV : Hydrogeology |
| Paper – 606 (<i>Practical</i>) | 75 | Unit – I : Engineering Geology Unit – II : Coal Geology Unit – III : Seminar Presentation Unit – IV : General Viva-voce (External) |

FIRST SEMESTER

PAPER – 101 (*Theory*)

[General Geology; Geomorphology & Basic Principles of Remote Sensing]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : General Geology 20

Scope of Geology and its relation to the different fundamental sciences; Different branches of Geology.

The Universe and Solar System; Earth as a planet; Origin and age of the earth; Physical parameters (size, shape, mass, density, rotation & revolution) of the earth; Major surface features of the earth – continents and ocean basins and their evolution.

Earth's interior; Use of seismic waves in the study of earth's internal structures.

Major internal processes of the earth; Volcanism and volcanoes; Types and distribution of volcanoes; Causes of earthquake; Earthquake belts; Prediction of earthquake; Earthquake zones of India and World.

Group – B : Geomorphology 20

Definition and time connotation of geomorphology.

Role of climate and tectonics on landscape development; Rock weathering, mass wasting and hill slope evolution; Geological actions by rivers, wind, glaciers, sea and their associated landforms.

Group – C : Basic Principles of Remote Sensing 20

Introduction to Remote Sensing; Electro-magnetic energy; Interaction of Electro-magnetic radiation with atmosphere and earth surface features; atmospheric windows; Energy sources for Remote Sensing; Sensor & platform; Spectral response curves; aerial photographs and satellite images; Advantages & limitations of Remote Sensing; Elements of image interpretation; Digital data.

Basic principles of photogrammetry.

PAPER – 102 (*Theory*)

[Crystallography & X-Ray Crystallography]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : Crystallography 45

Definition of minerals and its relation to crystal

Definition of crystal and amorphous substance; Crystallization and crystal growth; Unit cell; Symmetry operation and elements; Interfacial angle; External symmetry shown by the crystals; Point Groups; Definition and types of lattices; Significance of the lattice; Bravais lattices; Skew axis and Glide planes; Space Groups; Various crystal systems; Axial ratio; Parameters and indices; Crystal forms and habit; Symmetry notations of Hermann-Mauguin with relation to different crystal systems and conversion to total symmetry.

Study of 32 Point Groups or symmetry classes including forms, symmetry elements, stereogram and example of minerals.

Crystal intergrowth; Definition of twinning, Twin elements, Twin laws, Types of twin laws of different crystal systems, Twinning in feldspar group of minerals.

Crystallographic projections of Isometric, Tetragonal, Orthorhombic and Monoclinic systems; Determination of axial ratio.

Group – B : X-Ray Crystallography 15

Principles of X-ray crystallography.

Mineral identification by X-ray diffractometry

PAPER – 103 (*Practical*)

[Crystallography & Geomorphology]

[Total Marks : 40 (*External Evaluation*) + 10 (*Internal Evaluation*) = 50]

Unit – I : Crystallography 25

Study of the forms and symmetry elements of crystals belonging to the holohedral classes of Isometric, Tetragonal, Hexagonal, Orthorhombic,

Monoclinic & Triclinic systems and hextetrahedral, diploidal, gyroidal, tetragonal-scalenohedral, hexagonal-scalenohedral & trigonal-trapezohedral classes with the help of either natural crystals or wooden and glass models; Drawing of crystals in clinographic projections.

Study of twinning with the help of crystal models with reference to composition plane, twin plane and twin axis.

Stereographic projection and determination of axial ratios of crystal models of the holohedral classes of Isometric, Tetragonal, Orthorhombic and Monoclinic systems.

Unit – II : Geomorphology

15

Study of contours : Pattern of contours to indicate various topographical features; Interpretation of topographic maps; Drawing of profile and study of geomorphological features from topographic maps.

Model study of different geomorphic features

Suggested Books

General Geology & Geomorphology :

1. Physical Geology – R.F.Flint & B.J.Skinner; *John Wiley and Sons, Inc.*
2. Principles of Geology – J. Gilluly; A.C. Waters & A.O. Woodford; *W.H. Freeman & Company*
3. Physical Geology – C.C.Plummer & D.McGeary; *Wm. C. Brown Publishers.*
4. Geomorphology – A.L. Bloom; *Prentice Hall of India Pvt. Ltd.*
5. A Textbook of Geomorphology – P.Dayal; *Shukla Book Depot, Patna.*
6. Geomorphology – S.Singh; *Prayag Pustak Bhawan, Allahabad.*
7. Principles of Geomorphology – W.D.Thornbury; *John Wiley and Sons, Inc.*
8. Engineering and General Geology – P. Singh; (6th Edition); *S.K.Kataria & Sons*

Basic Principles of Remote Sensing :

1. Principles & Applications of Photogeology – S.N.Pandey; *New Age International Publishers.*
2. Remote Sensing Geology – R.P. Gupta; *Springer-Verlag*

Crystallography & X-Ray Crystallography :

1. Manual of Mineralogy (After J.D.Dana) – C.Klein & C.S.Hurlbut, Jr.; *John Wiley and Sons, Inc.*
2. Mineralogy – L.G.Berry & B.Mason (Revised by R.V.Dietrich); *CBS Publishers & Distributors.*
3. A Textbook of Mineralogy – E.S.Dana (Revised by W.E.Ford); *New Age International Publishers.*

4. Fundamentals of Optical, Spectroscopic and X-ray Mineralogy – S.Mitra; *New Age International Publishers*.
5. Laboratory Experiments in X-ray Crystallography – L.V. Azaroff & R.J. Donahue; *McGraw Hill Book Company, Inc.*

SECOND SEMESTER

PAPER – 201 (*Theory*) [Optical Mineralogy]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Scope & utility of optical mineralogy; Reflection and refraction of rays; Refractive index; Dispersion of light; Polarization of light (*plane or linear polarization, circular polarization & elliptical polarization*); Polarizer; Linear or plane polarization by doubly refracting crystals (*Nicol prism*), by differential absorption (*Polaroid*) and by reflection (*Brewster's Law*); Isotropic and anisotropic media.

Isotropic and Anisotropic (Uniaxial positive & negative and Biaxial positive & negative) minerals; Optic axis; Optical Indicatrix : Isotropic, Uniaxial & Biaxial indicatrices, their configuration and different sections within these indicatrices.

Opaque and non-opaque minerals; Petrological (refraction or transmitted-light) and Ore (reflection-light) microscope and their configuration; Orthoscopic and conoscopic arrangement of Petrological microscope; Accessory plates (*Mica Plate, Gypsum Plate & Quartz Wedge*) & their uses.

Properties of minerals in thin section : Colour; Pleochroism; Determination of pleochroic scheme; Relief; Shape or Form; Cleavage; Fracture; Double refraction; Birefringence; Determination of refractive index of minerals [*Liquid immersion method, Central illumination method (Becke Test) & Oblique illumination method*]; Extinction positions; Extinction angle (*straight or parallel, oblique & symmetrical extinction*); Interference colour & its determination; Determination of vibration direction.

Interference figure; Determination of optic sign; Measurement of optic axial angle.

Distinguishing Optical Characters of Some Important Non-opaque minerals:
Garnet group (*Garnet*); Olivine group (*Olivine*); Aluminosilicate group (*Sillimanite, Kyanite, Andalusite*); *Serpentine, Staurolite*; Pyroxene group (*Enstatite, Hypersthene, Augite, Diopside*); Amphibole group (*Actinolite, Hornblende*); Mica group (*Biotite, Muscovite*); Feldspar group [*Orthoclase, Microcline, Plagioclase (Albite to Anorthite)*]; Feldspathoid group (*Nephelene, Leucite*) and Silica group (*Quartz*); Carbonate minerals (*Calcite, Dolomite*).

PAPER – 202 (Theory) **[Physical & Descriptive Mineralogy]**

[Total Marks : 60 (External Evaluation) + 15 (Internal Evaluation) = 75]

Scope of Mineralogy; Definition of mineral; Physical properties of mineral, Relationship of physical properties with atomic structure; Mineral classification; Classification and structure of silicate minerals.

Study of physical & optical properties, atomic structure and chemistry of the following groups of mineral – Olivine, Garnet, Epidote, Pyroxene, Amphibole, Mica, Clay minerals, Silica, Feldspar and Feldspathoid.

Study of the following individual minerals – Sillimanite, Kyanite, Andalusite, Staurolite, Apatite, Chlorite, Zircon, Beryl, Calcite, Tourmaline, Magnetite, Ilmanite, Haematite, Spene and Rutile.

PAPER – 203 (Practical) **[Mineral Hand Specimens & Optical Mineralogy]**

[Total Marks : 40 (External Evaluation) + 10 (Internal Evaluation) = 50]

Unit – I : Mineral Hand Specimens 10

Study of the distinguishing characters and physical properties of the important silicate minerals and carbonate minerals (Calcite & Dolomite).

Unit – II : Optical Mineralogy 30

Study & Identification of the following minerals in thin section under Petrological Microscope :

Minerals with high to moderate relief : Garnet group (**Garnet**); Olivine group (**Olivine**); Aluminosilicate group (**Sillimanite, Kyanite, Andalusite**); **Serpentine; Staurolite**; Pyroxene group (**Enstatite, Hypersthene, Augite, Diopside**); Amphibole group (**Actinolite, Hornblende**); Mica group (**Biotite, Muscovite**).

Minerals with low relief : Feldspar group (**Orthoclase, Microcline, Plagioclase**); Feldspathoid group (**Nephelene, Leucite**) and Silica group (**Quartz**).

Minerals with variable relief : Carbonate minerals (**Calcite, Dolomite**).

Comparison of the refractive index of mineral in thin section with the help of central illumination method (Becke Test) [*isotropic & uniaxial minerals*].

Determination of vibration direction, pleochroic scheme and optical orientation of minerals under Petrological Microscope with the help of accessory plates.

Determination of the composition of plagioclase by Michael-Levy method.

Study under Petrological Microscope of uniaxial and biaxial interference figures and their recognition. Determination of optic sign from centered & offcentered uniaxial interference figures and centered acute bisectrix & centered optic axis biaxial interference figures by the use of accessory plates.

Suggested Books

Optical Mineralogy :

1. Optical Mineralogy – P.F.Kerr; *McGraw-Hill Book Company, INC.*
2. Fundamentals of Optical, Spectroscopic and X-ray Mineralogy – S.Mitra; *New Age International Publishers.*
3. Optical Mineralogy : The Nonopaque Minerals – W.R.Phillips & D.T.Griffen; *CBS Publishers & Distributors.*
4. Optical Crystallography – E.E.Wahlstrom; *John Wiley and Sons, Inc.*

Physical & Descriptive Mineralogy :

1. Manual of Mineralogy (After J.D.Dana) – C.Klein & C.S.Hurlbut,Jr.; *John Wiley and Sons, Inc.*
2. Mineralogy – L.G.Berry & B.Mason (Revised by R.V.Dietrich); *CBS Publishers & Distributors.*
3. A Textbook of Mineralogy – E.S.Dana (Revised by W.E.Ford); *New Age International Publishers.*
4. An Introduction to the Rock-Forming Minerals – W.A.Deer, R.A.Howie & J.Zussman; *ELBS Publishers with Longman.*

THIRD SEMESTER

PAPER – 301 (*Theory*) [Structural Geology & Geotectonics]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : Structural Geology

40

Definition & scope of Structural Geology; Primary, secondary & penecontemporaneous structures; Concept of non-diastrorphic and diastrorphic structures; Non-diastrorphic structures in sedimentary rocks : *stratification, current or cross bedding, graded bedding, ripple marks, unconformities, offlap, overlap, mud cracks & rain prints*; Determination of top and bottom or direction of younging of layered rocks; Non-diastrorphic structures in igneous rocks : *flow banding, flow layers, flow lines, schlieren, primary joints, vesicular & amygdaloidal structures, pillow structure, sheet structure, platy structure & perlitic structure*.

Physics of deformation :

Stress : Force, Traction & Stress; Normal stress & Shear stress; Stress at a point and Stress ellipsoid; Hydrostatic or Confining stress & Deviatoric or Directed stress; Stress acting on a plane; Mohr's stress circle.

Strain : Translation, rotation & deformation; Strain & Strain ellipsoid; Measurement of strain; Homogeneous & Inhomogeneous or Heterogeneous deformation or strain; Special types of homogeneous strain - axially symmetric extension, axially symmetric shortening and plane strain (pure shear & simple shear); Relationship between stress & strain.

Behaviour of rocks under stress : Elasticity, plasticity & brittleness; Stages of deformation; Factors of deformation – confining pressure or depth, temperature & time.

Diastrorphic structures : Planar & linear structures; Strike direction, dip angle, dip direction, plunge, bearing and use of the clinometer & Brunton compass.

Foliation : Compositional foliation, Disjunctive foliation, Crenulation foliation, Continuous foliation, Axial planar foliation, Transected foliation. Relationship of foliation to other structures.

Lineation : Classification of structural lineations; Discrete lineation, Constructed lineation, Fold-hinge lineation, Boudins, Structured lineations, slickensides, Mullions, Irregular mullions; Mineral lineation, Quartz rods.

Fold : Definition; Structural elements of single layer folded & multi layer folded surface; Morphological classification of fold based on sense of curvature, on direction of younging relative to sense of fold closure, on the symmetry of folds, on interlimb angle (after *Fleuty, 1964*), on the dip of the axial plane versus plunge of the fold axis (after *Fleuty, 1964*), on the nature of the hinge line, on the shape

of the hinge, on the number of hinges, on the geometrical relations among neighbouring structures; Geometrical classification of fold based on orthogonal thickness (t_{α}), axial trace thickness (T_{α}) and dip isogons (after *Ramsay, 1967*); Preliminary idea on the fold superposition & fold interference structure; Causes & mechanics of folding.

Fractures & Joints : Types of fractures : *Extension, Shear & Extensional shear*, Classification of joints; Relationship of fractures to other structures.

Faults : Different structural elements of faults; Classification & Types of faults : *high-angle fault, low-angle fault, dip-slip fault, strike-slip fault, oblique-slip fault, normal & reverse (thrust) fault, dip fault, strike fault, diagonal fault, bedding fault, radial fault, parallel fault, en-echelon fault, peripheral fault*; **Normal fault** – *definition, detachment fault, imbricate fault, synthetic fault, antithetic fault, horst & graben structure*; **Reverse (Thrust) fault** – *definition, overthrust, underthrust, nappe (thrust nappe & fold nappe), klippe, window or fenster, ramp-flat geometry, Imbricate structure or schuppen structure, duplex structure*; **Strike-slip fault** – *definition, transcurrent fault, wrench or tear or lateral fault, strike slip duplex, normal or negative flower structure or tulip structure & reverse or positive flower structure or palm-tree structure*.

Causes & mechanics of faulting, Anderson's genetic classification of faults.

Group – B : Geotectonics

20

Classical concept of Geosynclines – Definition, Classification and formation; Origin of mountains based on Geosynclinal theory.

Concept of Isostasy (*Gravitational Tectonics*).

Continental drift hypothesis, Sea floor spreading theory, Geomagnetism, Palaeomagnetism & Polar wandering curve.

Plate Tectonics – Definition, Nature & types of plate boundaries – convergent (subduction & collision), divergent and conservative (Transform fault); Triple point junctions.

Hot spots & Mantle plumes.

Brief outline of the structural features & tectonics of North East India.

PAPER – 302 (Theory)

[Petrology – I]

[Total Marks : 60 (External Evaluation) + 15 (Internal Evaluation) = 75]

Igneous rocks : **20**
Definition; Mode of occurrence; Textures & structures; Classification of igneous rocks on textural, mineralogical (*IUGS classification*), chemical & quasi-chemical (*C.I.P.W. classification*) criteria.

Sedimentary rocks : **20**
Introduction; Scope; Abundance of common sediments; Processes of formation of sedimentary rocks – weathering, transportation, deposition, diagenesis, compaction, cementation and recrystallisation; Mineralogical composition of sedimentary rocks; Provenance; Sedimentary cycle; Physico-chemical factors of sedimentation. Textures of sedimentary rocks – concepts of size, grade scale, sphericity & roundness; Statistical analyses of grain size and their implications; Description of Sedimentary structures – *lamination, ripple marks, current bedding, sand lineation, stylolites, geode, nodules & concretions, varves, penecontemporaneous deformation structures.*

Metamorphic rocks : **20**
Scope; Definition; Metamorphism & Metasomatism (*Isochemical & Allochemical Metamorphism*); Factors or Agents or Variables of Metamorphism; Types of Metamorphism; Depth Zones of Metamorphism; Facies & Facies Series of Metamorphism; Grades & Isogrades of Metamorphism; Textures & Structures of Metamorphic rocks.

PAPER – 303 (Practical)

[Exercise on Geological Contoured Maps, Structural Problems & Geological Field Work – I]

[Total Marks : 40 (External Evaluation) + 10 (Internal Evaluation) = 50]

Unit – I : Exercise on Geological Contoured Maps **15**

- a) Determination of dip and strike from bore hole data. Solution of three point problems.
- b) Completion of outcrops of beds from surface and borehole data.
- c) Interpretation of structures from geological maps with simple structures. Drawing of cross-section.

Unit – II : Structural Problems

15

- a) Use of Stereographic net (Wulf's net or Schmidt's net) in :
 - (i) Plotting of planes
 - (ii) Plotting of poles to the planes
 - (iii) Plotting of lines (plotting of plunge, bearing and pitch)
 - (iv) Determination of plunge & bearing of the line of intersection between two planes
 - (v) Determination of angle between two planes
 - (vi) Determination of apparent dip/dips in different directions in a plane
 - (vii) Determination of strike & true dip of a plane from apparent dip/dips
- b) Determination of the thickness of inclined beds by geometric construction to the scale.

Unit – III : GEOLOGICAL FIELD WORK – I :

10

1. Duration of the Fieldwork is to be minimum of 3 days.
2. An area with good rock exposures in the vicinity of the Institution (Local) is to be selected for this field trip.
3. Students are to be trained how to take readings like strike direction, amount & direction of dip; plunge & bearing; front bearing & back bearing with the help of Clinometer and Brunton Compass.
4. A short & concise Field report is to be submitted before the Third Semester (Final) Examination.
 - (a) **Field Work is compulsory** and students who do not attend the field work are to be declared 'Fail' in Paper – 303 even if they secure requisite pass marks in that paper.

Suggested Books

Structural Geology :

1. An outline of Structural Geology – B.E.Hobbs, W.D.Means & P.F.Williams; *John Wiley and Sons, Inc.*
2. Structural Geology – S.K.Ghosh; *Pergamon Press.*
3. Structural Geology – R.J.Twiss & E.M.Moores; *W.H.Freeman and Company.*
4. Structural Geology of Rocks and Regions – G.H.Davis (2nd Edition); *John Wiley and Sons, Inc.*

Geotectonics :

1. Aspects of Tectonics – K.S.Valdiya; *Tata McGraw-Hill Publishing Company Ltd.*
2. Plate Tectonics and Crustal Evolution – K.C.Condie; *Pergamon Press.*
3. Global Tectonics – P.Keary & F.J.Vine; *Blackwell Scientific Publications.*
4. The Evolving Continents – B.F.Windley; *John Wiley and Sons, Inc.*

Petrology – I (Basic Concepts) :

1. Principles of Petrology – G.W.Tyrrell; *B.I.Publications Pvt. Ltd.*
2. Petrology – E.G.Ehlers & H.Blatt; *CBS Publishers & Distributors.*
3. Petrology – W.T.Huang; *McGraw-Hill Book Company.*
4. Igneous and Metamorphic Petrology – M.G.Best; *CBS Publishers & Distributors*
5. Petrography – H.Williams; F.J.Turner & C.M.Gilbert; *CBS Publishers & Distributors.*
6. The Study of Rocks in Thin Section – W.W.Moorhouse; *CBS Publishers & Distributors.*
7. Sedimentary Petrology – E.J.Pettijohn; *CBS Publishers & Distributors.*
8. Petrology of Sedimentary Rocks – J.T.Greensmith; *CBS Publishers & Distributors.*
9. Metamorphic Petrology – B.W.D.Yardley; *ELBS/Longman*
10. Metamorphic Petrology – F.J.Turner; *McGraw-Hill Book Company*

FOURTH SEMESTER

PAPER – 401 (*Theory*) **[Crystal Chemistry & Geochemistry]**

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : Crystal Chemistry **25**

Chemical bonds; Elementary concepts of Isomorphism, atomic substitution, Polymorphism, Solid solution, defect lattice, Geological thermometry, packing & density, Co-ordination number.

Study of important types of structures – Halite (NaCl), Fluorite & Diamond.

Group – B : Geochemistry **35**

Cosmic abundance of elements; Composition of meteorites & lunar rocks; Geochemical classification of elements; Composition of crust, mantle and core of the earth.

Concept of partition coefficient, camouflage, capture and admittance.

Sedimentation as a geochemical process.

Preliminary idea on major and trace (including rare earth) elements

Distribution of major elements during magmatic crystallization.

Distribution of trace (including rare earth) elements in igneous, sedimentary & metamorphic rocks.

Principles of radioactive and stable isotopes in geochemistry.

PAPER – 402 (*Theory*)

[Petrology – II]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Igneous Petrology

20

Magma : Composition, origin & types; Nature of primary magma; Crystallization of magma; Reaction principle; Magmatic differentiation; Assimilation; Role of volatiles constituents in magmatic differentiation.

Thermodynamics of magmatic crystallization – Concepts of system, phase and component; Mineralogical Phase rule; Phase equilibria in igneous rocks : one, two & three component systems; Experimental observation of the following two component (binary) & three component (ternary) systems and their petrographical significance – (i) Diopside ($\text{CaMgSi}_2\text{O}_6$) – Anorthite ($\text{CaAl}_2\text{Si}_2\text{O}_8$) system [*Congruent melting*], (ii) Forsterite (Mg_2SiO_4) – Silica (SiO_2) system [*Incongruent melting*], (iii) Albite ($\text{NaAlSi}_3\text{O}_8$) – Anorthite ($\text{CaAl}_2\text{Si}_2\text{O}_8$) system [*Solid solution*] & (iv) Potash feldspar (KAlSi_3O_8)– Albite ($\text{NaAlSi}_3\text{O}_8$)– Silica (SiO_2) system.

Rock association (Consanguinity); Petrographic Province and Variation diagrams. Descriptive petrography & origin of the following rock families :

Granite – Rhyolite family

Syenite – Trachyte family

Gabbro – Basalt family

Ultrabasic & Ultramafic rocks

Brief petrographic discussion and origin of the following rock types : Lamprophyres; Anorthosite; Carbonatites; Deccan Traps & Ophiolites.

Sedimentary Petrology

20

Classification of sedimentary rocks; Classification of sandstone.

Preliminary concept about sedimentary environments and sedimentary facies.

Petrographic description of the following rocks :

Sandstone (*orthoquartzite, arkose, tritigra*), siltstone, shale, claystone, limestone, dolomite, marl, conglomerate & tritigrap.

Metamorphic Petrology

20

Concept of chemical equilibrium in metamorphism; Phase rule; Application of the phase rule to natural rocks; Metamorphic Phase diagrams (*Compositional Phase diagrams & P-T diagrams*); Metamorphic reactions & its types; Prograde or Progressive & Retrograde or Retrogressive Metamorphism; Influence of fluids on

metamorphic phase equilibria; Determination of Pressure-Temperature conditions of metamorphism (geothermobarometry): a preliminary idea.

Characteristic mineral assemblages and mineral reactions of trachytic, basic and calcareous (Pure, Impure & Calc-silicate) rocks belonging to different facies of regional dynamo-thermal metamorphism, and impure calcareous sedimentary rocks belonging to different facies of contact metamorphism (*Indian examples should be cited wherever applicable*); Descriptive Petrography of Quartzite, Granulite, Eclogite and Hornfels; Migmatites – their types & origin; Anatexis (or Palingenesis) & formation of granite.

Description & origin of the following Indian Stratigraphic rock types : *Charnockite, Khondalite, Gondite, Kodurite & Khasi Greenstone.*

PAPER – 403 (*Practical*) **[Igneous & Metamorphic Petrology]**

[Total Marks : 40 (*External Evaluation*) + 10 (*Internal Evaluation*) = 50]

a) Identification of the following rocks in hand specimens :

Various types of granite, granodiorite, syenite, aplite, gabbro, diorite, anorthosite, pegmatite, rhyolite, trachyte, andesite, dolerite, basalt, lamprophyres, serpentinite.

Slate, phyllite, various types of schists, gneiss, amphibolite, hornblende schist, granulite, Calc-silicate rocks, marble, quartzite, hornfels, augen gneiss, mylonite, migmatite, eclogite.

b) Textures and structures of igneous and metamorphic rocks in hand specimens.

c) Micro-textures and structures of igneous and metamorphic rocks (identification only).

d) Study & identification of following rocks in thin sections under trachygraphi microscope :

Granite, Granodiorite, Monzonite, Aplite, Syenite, Nepheline syenite, Gabbro, Norite, Dolerite, Anorthosite, Rhyolite, Trachyte, Basalt, Peridotite, Pyroxenite, Picrite, Dunite, Lamprophyre.

Chlorite schist, Biotite schist, Garnetiferous schist, Sillimanite schist, Amphibolite / Hornblende schist, Quartzite, Granulite.

Suggested Books

Crystal Chemistry & Geochemistry :

1. Manual of Mineralogy (After J.D.Dana) – C.Klein & C.S.Hurlbut, Jr.; *John Wiley and Sons, Inc.*
2. Principles of Geochemistry – B.Mason & C.B.Moore; *New Age International Publishers.*
3. Introduction to Geochemistry – K.B.Krauskopf; *McGraw-Hill Book Company.*
4. Geochemistry of Solid – W.F.Fyfe; *McGraw-Hill Book Company.*
5. Igneous Petrology – A.Hall; *ELBS Publishers with Longman.*

Igneous Petrology :

1. Principles of Petrology – G.W.Tyrrell; *B.I.Publications Pvt. Ltd.*
2. Petrology – E.G.Ehlers & H.Blatt; *CBS Publishers & Distributors.*
3. Petrology – W.T.Huang; *McGraw-Hill Book Company.*
4. Igneous Rocks – A.K.Gupta; *Allied Publishers Ltd.*
5. Igneous Petrology – A.R.McBirney; *CBS Publishers & Distributors.*
6. Igneous Petrology – A.Hall; *ELBS/Longman.*
7. Theoretical Petrology – T.F.W.Barth; *John Wiley and Sons, Inc.*
8. Petrology of Igneous and Metamorphic Rocks – D.W.Hyndman (2nd Edition); *McGraw-Hill Book Company.*
9. Igneous and Metamorphic Petrology – F.J.Turner & J.Verhoogen; *McGraw-Hill Book Company.*
10. Igneous and Metamorphic Petrology – M.G.Best; *CBS Publishers & Distributors*
11. Principles of Igneous and Metamorphic Petrology – A.R.Philpotts; *Prentice-Hall of India Pvt. Ltd.*
12. Petrography – H.Williams; F.J.Turner & C.M.Gilbert; *CBS Publishers & Distributors.*
13. The Study of Rocks in Thin Section – W.W.Moorhouse; *CBS Publishers & Distributors.*

Sedimentary Petrology :

1. Sedimentary Petrology – E.J.Pettijohn; *CBS Publishers & Distributors.*
2. Petrology of Sedimentary Rocks – J.T.Greensmith; *CBS Publishers & Distributors.*
3. Principles of Sedimentology – G.M.Friedman & J.E.Sanders; *John Wiley and Sons, Inc.*
4. Introduction to Sedimentology – S.M.Sengupta; *Oxford & IBH Publishing Company Pvt. Ltd.*
5. A Practical Approach to Sedimentology – R.C.Lindholm; *CBS Publishers & Distributors.*
6. Petrography – H.Williams; F.J.Turner & C.M.Gilbert; *CBS Publishers & Distributors.*

Metamorphic Petrology :

1. Petrogenesis of Metamorphic Rocks : H.G.F. Winkler; *Springer-Verlag, New York Inc.*

2. Metamorphic Petrology – B.W.D.Yardley; *ELBS/Longman*
3. Metamorphic Petrology – F.J.Turner; *McGraw-Hill Book Company*
4. Petrology of Igneous and Metamorphic Rocks – D.W.Hyndman (2nd Edition); *McGraw-Hill Book Company*
5. Igneous and Metamorphic Petrology – M.G.Best; *CBS Publishers & Distributors*
6. Principles of Igneous and Metamorphic Petrology – A.R.Philpotts; *Prentice-Hall of India Pvt. Ltd.*
7. Igneous and Metamorphic Petrology – F.J.Turner & J.Verhoogen; *McGraw-Hill Book Company.*
8. Petrography – H.Williams; F.J.Turner & C.M.Gilbert; *CBS Publishers & Distributors.*
9. The Study of Rocks in Thin Section – W.W.Moorhouse; *CBS Publishers & Distributors.*
10. Petrography of the Igneous and Metamorphic Rocks of India – S.C.Chatterjee; *The Macmillan Company of India Ltd.*
11. Metamorphism and Metamorphic Rocks of India – S.Ray; *K.P.Basu Publishing Company.*

FIFTH SEMESTER

PAPER – 501 (*Theory*) **[Principles of Stratigraphy & Historical Geology]**

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Principles of Stratigraphy & Historical Geology

A brief survey of classical geological reconnaissance; Superposition of strata; Warner and Neptunism; Hutton and Uniformitarianism & Plutonism; Smith and Applied Stratigraphy; Lyell's Principles of Geology.

The Geological Time Scale and preliminary idea of crustal and biological evolution of earth through the geologic time; Earth during different geologic time periods.

Stratigraphic classification & nomenclature – concepts of Time (Chronological), Time-Rock (Chronostratigraphic), Rock (Lithostratigraphic) & Biostratigraphic units.

Geochronology; Absolute geological time; Methods of measurement of geological time – rate of sedimentation, salinity, radio-activity.

Principles of Stratigraphic Correlation.

Sedimentary environments : elements and factors of environment; Classification of sedimentary environments.

Sedimentary facies

Preliminary concepts of sequence stratigraphy, seismo-stratigraphy and magnetostratigraphy.

A brief outline of the geology of India – Precambrian to Recent.

PAPER – 502 (*Theory*)

[Indian of Stratigraphy]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Indian Stratigraphy

A brief study of the Precambrian stratigraphy of India of the following areas with respect to lithology, tectonics and igneous activity : (a) Dharwar Province (Karnataka); (b) Singhbhum-Orissa Province (Jharkhand & Orissa); (c) Assam-Meghalaya plateau (Shillong plateau); (d) Aravalli-Bundelkhand Province (Rajasthan); (e) Eastern Ghats Province; (f) Central Indian Province (Madhya Pradesh & Chattishgarh); (g) Cuddapah Super Group of Cuddapah basin; (h) Vindhyan Super Group of Sone Valley.

A brief study of the problems of correlation of the Precambrian rocks occurrences in India.

Introduction to Palaeozoic and Mesozoic Eras and study of the following areas with emphasis on the points mentioned (**a** to **h**) :

- (b) Palaeozoic of the Salt Range and Spiti – *Stratigraphic succession, lithology, palaeontology and age.*
- (c) Gondwana of Peninsular and Extra-peninsular India – *Classification, lithology, palaeontology, palaeogeography, igneous activity, structure and economic importance.*
- (d) Mesozoic of the Salt Range and Triassic of Spiti – *Palaeontology and lithology.*
- (e) Jurassic of Cutch – *Palaeontology and lithology.*
- (f) Cretaceous of South India and NE India – *Palaeogeography, palaeontology and lithology, and their relationship.*
- (g) Deccan Traps – *Distribution, lithology and age.*
- (h) Tertiary & Quaternary of NE India – *Lithology, palaeontology, structure and economic importance.*
- (i) Siwaliks – *Lithology, palaeogeography and distribution.*

PAPER – 503 (*Theory*)

[Palaeontology & Soil Geology]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : Palaeontology 45

Principles of Palaeontology 15

Scope of palaeontology; Different branches of palaeontology; Definition & kinds of fossils; Mode of preservation of fossils.

Importance of fossils in – chronological, palaeogeographical, palaeoecological, biostratigraphical, stratigraphical, evolutionary and economic studies.

Descriptive Palaeontology 30

Broad divisions of invertebrates into different phyla and their major characteristics.

A study of the morphological characters and brief geological distribution of the following phyla/classes – Foraminifera, Brachiopoda, Anthozoa, Mollusca, Arthropoda (Trilobita), Echinodermata (Echinoidea), Graptoloidea.

A general idea of the plant fossils of India with special reference to Gondwana Flora and their palaeogeographic significance.

Vertebrate fossils and their importance in palaeontology & stratigraphy; A short discussion on the evolutionary trend of **Man**, **Equidae** and **Proboscidea**.

Scope of microfossils with special reference to oil exploration.

Group – B : Soil Geology 15

Definition of soil; Processes of soil formation; Physical properties of soil; Soil profile and classification of soil; Soil types of India; Soil erosion and conservation of soil.

PAPER – 504 (*Theory*) **[Hydrogeology and Remote Sensing & GIS]**

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : Hydrogeology 30

Ground water distribution; Ground water source; Occurrence & origin; Factors affecting ground water supply; Porosity; Permeability; Hydrological properties of water bearing materials; Types of openings in rocks; Primary & secondary openings.

Water table – Definition & location; Free & confined water; Aquifers; Water table in consolidated and unconsolidated rock formations; Selection of sites for sinking wells.

Ground water provinces of India.

Group – B : Remote Sensing & GIS 30

Orbital parameters of Remote Sensing satellites, Geostationary satellites; LANDSAT, ICONOS, RADARSAT, IRS & CARTOSAT satellites.
Microwave and thermal remote sensing; Advantages and disadvantages of Radar image; Characteristics of thermal image.

False Colour Composit (FCC)

Application of remote sensing in geomorphological, structural and lithological mapping; Natural Hazard Mitigation

Introduction to GIS – Digital Geospatial database; Vector & Raster data; Overlay analysis

PAPER – 505 (*Practical*) **[Sedimentary Petrology & Palaeontology]**

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Unit – I : Sedimentary Petrology 30

- a) Mechanical analysis of loose sediments using atleast four standard sieves. Representing the data by histogram and preparation of cumulative curves. Determination of mean & median diameter.

- b) Study of sphericity & roundness of sediment grains by visual method using power scale.
- c) Identification and study of the following rocks in hand specimens :
Conglomerate, Breccia, Sandstone (Orthoquartzite, Arkose, Graywacke), Grit, Shale, Oilshale, Claystone, Limestone, Oolitic limestone, Fossiliferous limestone, Marl, Evaporites, Ferruginous rocks.
- d) Study and identification of following sedimentary structures :
Lamination, Ripple marks, Current bedding, Sand lineation, Stylolites, Geode, Nodules & Concretions, Verves.
- e) Identification & study of heavy minerals and quartz types in thin sections.
- f) Study of limestone in thin section and identification of the rock on the basis of allochems and orthochems.

Unit – II : Palaeontology

30

- a) Identification of the following genera of fossils by their external morphology. Their stratigraphic ranges will also have to be studied :
 - (i) Nummulites, Alveolina, Discocyclina
 - (ii) Calceola, Zaphrentis, Favosites, Isastrea
 - (iii) Cidaris, Hemiaster, Micraster, Echinolampus, Clypeaster, Stygmatoptygus
 - (iv) Orthis, Productus, Spirifer, Terebratula, Pentamerus, Rhynchonella, Syringothyris
 - (v) Arca, Cardita, Exogyra, Glycemeris, Pecten, Plicatula, Ostrea, Trigonina
 - (vi) Bellerophon, Conus, Conularia, Cyprea, Cerethium, Fusus, Murex, Natica, Physa (Bulinus), Turritella, Voluta
 - (vii) Baculites, Belemnites, Ceratites, Hamites, Goniatite, Nautilus, Perisphineres, Stephenoceras
 - (viii) Calymene, Phacops
 - (ix) Monograptus, Diplograptus
 - (x) Glossopteris, Gangamopteris, Ptillophyllum, Vertebraria
- b) Interpretation and determination of stratigraphic range from the fossil assemblages from **Cretaceous of Tiruchchirappalli** and **Jurassic of Cutch (Kachchh)**.

[In case of non-availability of fossils, representative casts of fossils may be used in Exercise – a & b]

PAPER – 506 (*Practical*)
[Surveying, Indian Stratigraphic Rocks & Geological Field Work – II]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Unit – I : Surveying **10**

Topographic survey with the help of Plane Table and Prismatic Compass (*Open & Close traverse*).

Estimation of 'front bearing' and 'back bearing' with the help of Clinometer and Brunton Compass.

Unit – II : Indian Stratigraphic Rocks **10**

a) Recognition of the following Indian stratigraphic rocks in hand specimens :

Charnockite, Basic Charnockite, Leptynite, Gondite, Khondalite, Kodurite, Khasi Greenstone, Myllem Granite.

Unit – III :

(a) GEOLOGICAL FIELD WORK – II : **30**

1. Duration of the Fieldwork is to be minimum of 10 days.
2. An area of about 10-sq. km. is to be geologically mapped; planar and linear structures to be plotted using standard geological symbols.
3. Rock specimens collected from the field are to be identified and labelled. These (atleast 5 representative rock specimens) are to be submitted during the viva-voce.
4. Visit to areas of economic mineral occurrences, industrial belts, mining operations, drill sites as well as visit to Institutions related to geological activities.
5. A detailed Field Report along with the geological map (*prepared by the students*) is to be submitted before the Fifth Semester (Final) Examination.
6. **Field Work is compulsory** and students who do not attend the field work are to be declared 'Fail' in Paper – 506 even if they secure requisite pass marks in that paper.

(b) Viva-voce on Geological Field Work – II **10**

Viva-voce is to be conducted by the External Examiner in presence of the Field supervisor/s of the concerned institution.

Suggested Books

Principles of Stratigraphy :

1. Stratigraphic Principles and Practices – J.M.Weller; *Universal BookStall, Delhi.*
2. Principles of Stratigraphy – C.O.Dunbar & J.Rodgers; *John Wiley and Sons, Inc.*
3. Stratigraphy and Sedimentation – W.C.Krumbein & L.L.Sloss; *W.H.Freeman & Company.*
4. Principles of Stratigraphy – R.R.Lemon; *Merrill Publishing Company.*

Indian Stratigraphy :

1. Geology of India and Burma – M.S.Krishnan; *CBS Publishers & Distributors.*
2. Fundamentals of Historical Geology and Stratigraphy of India – R.Kumar; *New Age International Publishers.*
3. Geology of India – D.N.Wadia; *Tata McGraw-Hill Publishing Company Ltd.*
4. Precambrian Geology of India – S.M.Naqvi & J.J.W.Rogers; *Oxford University Press.*
5. Indian Precambrian – B.S.Paliwal (Ed.); *Scientific Publications (India), Jodhpur.*

Palaeontology :

1. Palaeontology Invertebrate – H.Wood; *CBS Publishers & Distributors.*
2. Principles of Invertebrate Paleontology – R.R.Shrock & W.H.Townshofel; *CBS Publishers & Distributors.*
3. Invertebrate Fossils – R.Moore; C.G.Lalicker & A.G.Fishwr; *McGraw-Hill Book Company.*
4. Principles of Paleontology – Raup & Stanley; *CBS Publishers & Distributors.*
5. A Textbook of Palaeontology – A.K.Sen; *Modern Book Agency Pvt. Ltd.*
6. Vertebrate Palaeontology – A.S.Romer; *Oxford University Press.*
7. Evolution of the Vertebrates – E.H.Colbert; *New Age International Publishers.*
8. Microfossils and their Applications – P.K.Kathal; *CBS Publishers & Distributors.*

Hydrogeology :

1. Groundwater Hydrology – D.K.Todd (2nd Edition); *John Wiley and Sons, Inc.*
2. Evolution and Development of Groundwater – G.Mahajan; *Ashish Publishing House.*
3. Ground Water – C.F.Tolman; *McGraw-Hill Book Company.*

Soil Geology :

1. Basic Concept of Soil Science – A.K.Kolay; *New Age International Publishers.*
2. Fundamentals of Soil Science – H.O. Foth; *John Wiley and Sons, Inc.*
3. Studies on Soils of India – S.V. Govinda Rajan & H.G. Gopala Rao; *Vikas Publishing House Pvt. Ltd.*

Remote Sensing & GIS :

1. Principles & Applications of Photogeology – S.N.Pandey; *New Age International Publishers.*
2. Remote Sensing Geology – R.P. Gupta; *Springer-Verlag.*
3. Remote Sensing & Image Interpretation – T.M. Lillesand & R.W. Kiefer; *John Wiley & Sons, Inc.*
4. Remote Sensing Applications in NE India – S.C. Goswami (Ed.); *Purbanchal Prakash.*
5. Interpretation of Airphotos & Remotely Sensed Images – R.H. Arnold; *Prentice-Hall, Inc.*
6. An Introduction to Geographical Information Systems – I. Heywood, S. Cornelius & S. Carver; *Longman Group.*

SIXTH SEMESTER

PAPER – 601 (*Theory*) **[Ore Genesis & Prospecting]**

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : Ore Genesis 40

Scope of Economic Geology; Definition of ore, ore deposit, gangue, tenor, host rock; Concept of ore genesis; Processes of formation of economic mineral deposits with Indian examples; Classification of economic mineral deposits; Mode of occurrence of ore bodies; Concept of paragenesis and zoning of ores; Definition of metallogenetic belts, epochs and provinces with examples; Wall rock alteration; structural, physico-chemical and stratigraphic control of ore localization with examples.

Group – B : Prospecting 20

Methods of geological, geophysical, geochemical and geobotanical prospecting.

PAPER – 602 (*Theory*) **[Indian Mineral Deposits & Mineral Economics]**

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Group – A : Indian Mineral Deposits 50

A study of mineralogy, mode of occurrence, origin and uses of the following economic mineral deposits with reference to Indian occurrences :

- (a) Metallic mineral deposits : Aluminum, Copper, Chromite, Iron, Manganese, Lead & Zinc, Gold, Silver, Nickel and Radioactive minerals.
- (b) Non-metallic mineral deposits : Limestone, Mica, Clay, Sillimanite, Asbestos, Diamond.
- (c) Industrial Raw materials : Cement, Glass & Ceramics, Fertilizer, Refractory, Abrasive, Strategic minerals, Gemstones and Building materials.

Group – B : Mineral Economics

10

Concept of Mineral Economics; Strategic, critical & essential minerals; National Mineral Policy.

PAPER – 603 (Theory) **[Environmental Geology & Engineering Geology]**

[Total Marks : 60 (External Evaluation) + 15 (Internal Evaluation) = 75]

Group – A : Environmental Geology

30

Definition and scope of Environmental Geology; Natural and anthropogenic environmental hazards; Landslide & flood, and their impact on environment; Impact of mining on environment; Environmental pollution; Seismic vulnerability and seismic hazard assessment parameters.

Group – B : Engineering Geology

30

Role of geologists in construction of dams, tunnels, highways and bridges; Geological and geophysical investigation of damsites; Foundation and abutment problems – seepage; grouting.

Study of landslides: causes and mitigation.

Engineering properties of soils.

PAPER – 604 (Theory) **[Fuel Geology & Mining Geology]**

[Total Marks : 60 (External Evaluation) + 15 (Internal Evaluation) = 75]

Group – A : Fuel Geology

40

- (a) Petroleum – Chemical composition; Definition of source rock, reservoir rock, cap rock & traps; Origin of petroleum; Migration & accumulation; Occurrence of petroleum; Brief idea about the petroliferous basins of India; Oilfields of NE India.
- (b) Coal – Definition; Physical properties, rank, type, grade & class of coal; Chemical constituents of coal; Origin of coal – In situ and Drift theory; Coal deposits of India with special reference to NE India.
- (c) Atomic minerals - Mineralogy, occurrence and distribution in India.

- (d) Non-Conventional Energy – Hydropower, solar energy, wind energy, geothermal energy, wave energy

Group – B : Mining Geology **20**

An introduction to mining; Mining terminology in open cast & underground mine; Mining methods with respect to following : open cast, breast stoping, cut & fill, sub-level caving, board & pillar and longwall method; Mine ventilation.

Methods of sampling and their applications.

PAPER – 605 (*Practical*)

[Economic Geology, Reserve Estimation & Ore Microscopy, Remote Sensing and Hydrogeology]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Unit – I : Economic Geology **30**

- a) Recognition of the following economic minerals in hand specimens :

Apatite, Arsenopyrite, Asbestos, Axinite, Barite, Bauxite, Bornite, Calcite, Chalcopyrite, Chromite, Cinnabar, Covellite, Coal, Corundum, Cryolite, Cuprite, Dolomite, Fluorite, Galena, Graphite, Gypsum, Haematite, Laterite, Limonite, Magnesite, Magnetite, Malachite, Molybdenite, Monazite, Orpiment, Pyrite, Pyrolusite, Psilomelane, Pyrrhotite, Realgar, Rhodocrosite, Siderite, Sphalerite, Stibnite, Sulphur, Zincite,

Identification of groups of economic mineral assemblages for the following industries :

- (i) Ceramic; (ii) Cement; (iii) Iron & Steel; (iv) Fertilizer.

- b) Identification of constructional material for roads and buildings.

Unit – II : Reserve Estimation & Ore Microscopy **10**

Ore reserve estimation on bedded deposits.

Microscopic Identification of Haematite, Magnetite, Galena, Sphalerite & Chalcopyrite.

Unit – III : Remote Sensing **10**

Stereo Vision test, Use of Pocket Stereoscope, Visual interpretation of satellite image for interpretation of lineament, lithology and structure.

Unit – IV : Hydrogeology **10**

Preparation and interpretation of water table maps.

Analysis of rainfall data.

PAPER – 606 (*Practical*)

[Engineering Geology, Coal Geology, Seminar Presentation and General Viva-voce]

[Total Marks : 60 (*External Evaluation*) + 15 (*Internal Evaluation*) = 75]

Unit – I : Engineering Geology **15**

Determination of Liquid limit, Plastic limit, Plasticity index, Coefficient of shear and angle of internal friction from supplied data.

Unit – II : Coal & Strategic Minerals **10**

Study of Coal in hand specimens and in thin section.

Unit – III : Seminar Presentation **20**

Every student is to present & deliver a seminar on any topic chosen from the subjects included in this syllabus from First Semester to Sixth Semester. The faculty members of the concerned department are to evaluate the presentation.

Unit – IV : General Viva-voce **15**

External Examiner is to conduct the Viva-voce and he/she may ask questions to the students on any topic from the subjects included in this syllabus from First Semester to Sixth Semester.

Suggested Books

Ore Genesis :

1. Economic Mineral Deposits – M.L.Jensen & A.M.Bateman (3rd Edition); *John Wiley and Sons, Inc.*

2. Ore Deposits – C.F.Park,Jr. & R.A.MacDiarmid; *W.H.Freeman and Company*.
3. Studies of Mineral Deposits – V.I.Smirnov (Ed.); *Mir Publishers, Moscow*.

Prospecting and Mining Geology :

1. Elements of Prospecting for Non-fuel Mineral – P.K. Banerjee & S. Ghosh; *Allied Publishers Ltd*.
2. Prospecting of Minerals – Y.D. Kitaisky; *Foreign Language Publishing House, Moscow*
3. Geophysical Prospecting – M.B. Dobrin; *McGraw Hill Book Company, Inc*.
4. Courses in Mining Geology – R.N.P.Arogyaswamy; *Oxford & IBH Publishing Company Pvt. Ltd*.
5. Mining of Ores and Non-Metallic Minerals – M.Agoshkov; S.Borisev & V.Boyarsky; *Mir Publishers, Moscow*.
6. Introductory Mining Engineering - H.L.Hartman; *John Wiley and Sons, Inc*.

Indian Mineral Deposits :

1. Mineral Resources of India – D.K.Banerjee; *World Press Pvt. Ltd*.
2. Ore Deposits of India – K.V.G.K.Gokhale & T.C.Rao; *Affiliated East-West Press Pvt. Ltd*.
3. Economic Geology (Economic Mineral Deposits) – U.Prasad; *CBS Publishers & Distributors*.
4. A Handbook of Economic Geology – A.K.Sen; *Modern Book Agency Pvt. Ltd*.
5. Minerals of India – D.N.Wadia (Ed.); *National Book Trust*.

Mineral Economics :

1. Mineral Economics – R.K.Sinha & N.L.Sharma; *Oxford & IBH Publishing Company Pvt. Ltd*.

Environmental Geology :

1. Environmental Geology (Indian Context) – K.S.Valdiya; *Tata McGraw-Hill Publishing Company Ltd*.
2. Environmental Geology – B.W.Murck, B.J.Skinner & S.C.Porter; *John Wiley and Sons, Inc*.
3. Textbook in Environmental Sciences – V.Subramaniam; *Narosa International*.

Engineering Geology :

1. Engineering and General Geology – P. Singh; (6th Edition); *S.K.Kataria & Sons*.
2. A Geology for Engineers – F.G.H.Blyth & M.H.deFreitas; *ELBS/Longman*.
3. Text Book of Engineering Geology – N.C. Kesanulu; *Macmillan India Ltd*.
4. Geology for Engineers – D.S. Arora; *CBS Publishers & Distributors*.

Fuel Geology :

1. Geology of Petroleum – A.I.Leveresen; *W.H.Freeman and Company*.
2. Petroleum and Coal – P.K.Das & H.Baruah; *M.D.Publications Pvt. Ltd., Delhi*.
3. Petroleum Geology – K.K. Landes; *John Wiley & Sons, Inc*.
4. Petroleum Geology – F.K. North; *Unwin-Hyman*.
5. The World of Petroleum – B.G. Deshpande; *Wiley Eastern Ltd*.

6. Coal – D.W. Van Krevelen; *Elsevier Scientific Publishing Company*.
7. Coal Resources of India – R.M. Singh; *Allied Publishers Ltd*.
8. Non conventional Energy Sources – G.D. Rai; *Khanna Publishers*.
9. Non conventional Energy Sources – A. Gupta; *Umesh Publications*.
10. Non conventional Energy Sources – B.H. Khan; *E-Book (downloadable from internet)*.
11. Atomic and Non-Conventional Energy – S. Tiwari; *Anmol Publications*.
12. Atomic Energy : a New Start – D. E. Lilienthal; *HarperCollins*.

